Item 546-D GAO 13: EMD-81-110

JUL 7 1981

BY THE U.S. GENERAL ACCOUNTING OFFICE

Report To The Chairman, Subcommittee On Energy Development And Applications Committee On Science And Technology House Of Representatives

Elimination Of Federal Funds For The Heber Project Will Impede Full Development And Use Of Hydrothermal Resources

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High-temperature hydrothermal resources have a significant potential for generating electricity which can help reduce the Nation's dependence on fossil fuels. The majority of these resources, however, can only be efficiently used with binary cycle geothermal technology.

The Department of Energy was sharing the cost of the Heber binary cycle geothermal demonstration project to show the viability of binary cycle geothermal powerplants and stimulate the use of this technology. However, the administration has proposed to eliminate Federal funding of this project. The administration believes that private industry should solely undertake this demonstration project.

The elimination of Federal funding for this project could cause it to be terminated. Private industry currently cannot undertake this project, because of its high technical risks and economic uncertainties, without the assistance of the Government. Industry does not intend to use binary cycle geothermal technology until its commercial feasibility has been demonstrated. Consequently, the use of this technology will be delayed, thereby impeding the full development and widespread use of hydrothermal resources.

EMD-81-110

JUNE 25, 1981

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ENERGY AND MINERALS
DIVISION

B-203745

The Honorable Don Fuqua
Chairman, Subcommittee on Energy
Development and Applications
Committee on Science and Technology
House of Representatives

Dear Mr. Chairman:

On November 12, 1980, the Chairman of the Subcommittee on Energy Research and Production, House Committee on Science and Technology, requested we examine the Department of Energy's (DOE's) performance in demonstrating the feasibility of geothermal electric powerplants. Oversight responsibility for geothermal energy has since been transferred to your Subcommittee and, as agreed with your office, we focused our work on addressing the administration's proposal to eliminate funds for the Heber binary cycle geothermal demonstration project, and the effects this funding elimination will have on the further development and use of hydrothermal resources (one form of geothermal energy) for generating electricity.

As you know, the administration proposes to eliminate Federal funding for the Heber demonstration project because it believes that the Government should not be involved in commercialization activities. The Heber project is a proposed, first-of-a-kind, 50-Megawatt electric (MWe) geothermal powerplant intended to demonstrate the feasibility of binary cycle technology on a commercial-scale. DOE was to have shared equally with industry in the plant's projected cost of $122.8 million, plus incur an additional $8.6 million for equipment to monitor and collect data on the performance of the project. If the plant was successful, DOE was to have shared in its revenues. The administration believes that a Federal role in this and other demonstration projects is not appropriate because these projects represent commercialization activities which belong in the private sector. The administration has stated that the Government's focus should be on research and development efforts which are long-term, high-risk, and have high potential payoffs. The administration further believes that private industry is to be relied on to

complete this geothermal demonstration project and to eventually bring about the commercial use of binary cycle geothermal applications.

To address the effects the proposed funding elimination will have on the further development and use of hydrothermal resources, we directed our work toward answering the following key questions.

--What is the potential energy contribution from hydrothermal resources, and how important is binary cycle technology for purposes of realizing that potential?

--Why are binary cycle geothermal powerplants not in commercial use?

--What purpose would be served by the Heber binary cycle demonstration plant?

--What are the prospects for project continuation and further development and use of hydrothermal resources once Federal project funding is eliminated?

To answer these questions, we examined the status of and potential for developing hydrothermal resources, the use of binary cycle technology on these resources, the purposes and objectives of the Heber project, and the rationale for eliminating funding for the project. Our examination included discussions with program officials in DOE's Washington, D.C., headquarters office as well as DOE's San Francisco and Idaho Operations Offices and with representatives of the utilities participating in the project. We also obtained and reviewed DOE's past and current budgets as well as its program plans in regard to the overall development of geothermal energy; various studies performed for DOE relating to hydrothermal resources and the use of binary cycle technology on these resources; the cooperative agreement for the construction and operation of the Heber project; DOE internal audit reports relating to binary cycle technology development; and various other DOE documents which discussed binary cycle development activities. Additionally, we reviewed studies by the U.S. Geological Survey on the potential of hydrothermal resources and studies by private industry, most notably the Electric Power Research Institute, on the status of binary cycle technology.

We also obtained information on hydrothermal resources and the binary cycle technology from representatives of industry and State governments in six States which contain

hydrothermal resources with the potential for generating electricity using binary cycle technology--California, Idaho, Nevada, Oregon, Utah, and Washington. We discussed the Heber demonstration project and its impact with the respective State public utility commissions, State energy offices, geothermal developers, and the utilities located near the available hydrothermal resources. We obtained from these organizations the prospects and current plans for using binary cycle technology on the hydrothermal resources in their areas and obtained and analyzed relevant reports prepared by these groups dealing with the development of hydrothermal resources. We also contacted a limited number of lending institutions with knowledge and experience in geothermal electric power projects to obtain their views on the financing of binary cycle geothermal projects.

The details of our review are discussed in the appendix to this letter, and the results are highlighted below. Our review showed that the Heber project offers an opportunity which can lead to making optimum use of a substantial energy resource. However, without continued Federal funding for the project, there is little likelihood that the project will proceed. Consequently, this opportunity may be lost, thereby delaying the widespread use of binary cycle geothermal technology on hydrothermal resources.

Although hydrothermal resources have a significant potential for reducing the Nation's dependence on fossil fuels, realizing that potential depends on the full development of binary cycle technology. High-temperature hydrothermal resources may exist with the potential to generate as much as 150,000 MWe, which is equivalent to one-fourth of the current installed electric capacity in the Nation. DOE has estimated that about 25,000 MWe of power from hydrothermal resources could be on-line by the year 2000 assuming continuation of its aggressive program. The major portion of hydrothermal's potential for generating electricity will be achieved with binary cycle technology, which is the only technology with the potential to efficiently use most of the Nation's high-temperature hydrothermal resources.

However, there currently exists many technical risks and economic uncertainties with this technology which are impeding the commercial use of binary cycle geothermal powerplants. The utility industry has indicated that it needs a commercial-sized, 50-MWe demonstration plant to reduce these risks and to show the viability of the commercial use of binary cycle geothermal powerplants. All segments of the utility industry believe that satisfactory operation of the Heber plant will

provide the information needed to stimulate the use of binary cycle powerplants.

Without continued Federal participation in funding the Heber project, however, it appears that the project will be terminated. The private industry participants in the project indicated that they do not have the funds to complete the project and are not willing to undertake this project, with its associated risks, on their own. Consequently, indications are that industry will not commercialize binary cycle technology at this time, thereby delaying development of binary cycle geothermal powerplants and the possible widespread use of hydrothermal resources.

As our report was nearing completion, actions were initiated in the Congress which indicate that the Heber binary cycle geothermal demonstration project may be continued. Both the House Committee on Science and Technology and the Senate Committee on Energy and Natural Resources, in their respective fiscal year 1982 DOE authorization bills, included provisions for the continuation of the Heber project. The results of our work support such action. The Heber project provides an opportunity to begin achieving the widespread use of binary cycle technology and bring to fruition the Federal investment, approximately $121 million in the past 4 years, in developing the technology. Because of technical and economic uncertainties, continued Federal participation appears necessary for the project to proceed and act as a catalyst in reducing the risks and stimulating the use of binary cycle geothermal powerplants. It is worth noting in this regard that, if the project is successful, the majority of the Federal funds in the project could be recovered from plant operations.

As requested by your office, we did not obtain agency comments on this report but as agreed, we did discuss the report with DOE officials within the Office of the Assistant Secretary for Conservation and Renewable Energy. They generally agreed with our conclusions.

We are sending copies of this report to the Chairmen, House Committee on Science and Technology and the House and Senate Committees on Appropriations, the Secretary of Energy, and other interested parties. In the event the fiscal year 1982 DOE authorization bills are submitted to a House and

Senate conference committee, we plan to make distribution to the Chairman and members of that committee. We will also make copies available to others upon request.

Sincerely yours,

J. Dexter Peach
Director

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ABBREVIATIONS

C	Celsius
DOE	Department of Energy
MWe	Megawatt electric
SDG&E	San Diego Gas and Electric Company

APPENDIX I

ELIMINATION OF FEDERAL FUNDS FOR THE HEBER PROJECT WILL IMPEDE FULL DEVELOPMENT AND USE OF HYDROTHERMAL RESOURCES

On November 12, 1980, the Chairman of the Subcommittee on Energy Research and Production, House Committee on Science and Technology, requested the General Accounting Office to assess the Department of Energy's (DOE's) performance in demonstrating the feasibility of geothermal electric powerplants. Oversight responsibility for geothermal energy was subsequently transferred to the Subcommittee on Energy Development and Applications. Because of the administration's proposal to eliminate funding for geothermal activities, the Subcommittee staff requested that we focus our work on addressing the proposed elimination of funds for the Heber 50-Megawatt electric (MWe) binary cycle geothermal demonstration powerplant, and the effects this funding elimination will have on the further development and use of hydrothermal resources.

To address this request, our work was directed towards answering the following questions.

--What is the potential energy contribution from hydrothermal resources, and how important is binary cycle technology for purposes of realizing that potential?

--Why are binary cycle geothermal powerplants not in commercial use?

--What purpose would be served by the Heber binary cycle demonstration plant?

--What are the prospects for project continuation and further development and use of hydrothermal resources once Federal project funding is eliminated?

BACKGROUND

In the past few years, DOE has maintained an ambitious program to develop and promote the use of various geothermal energy resources. Between fiscal years 1978 and 1981, DOE has been appropriated about $576 million for geothermal energy activities. These funds were used for a wide range of research, development, and commercialization activities to help bring about the development and use of geothermal energy applications. Approximately $121 million of this amount has been spent on the development of the binary cycle technology.

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Included among these activities is DOE's participation in the Heber 50-MWe binary cycle geothermal demonstration powerplant project. This project was undertaken in response to the congressional requirements contained in the Conference Report to the Energy and Water Development Appropriation Act of 1980 (Public Law 96-69, Sept. 25, 1979) which directed DOE to proceed with the development of a 50-MWe binary cycle geothermal demonstration plant. In response to this requirement, DOE entered into a cooperative agreement with San Diego Gas and Electric Company (SDG&E) to construct a 50-MWe powerplant in Heber, California. Under the agreement, which was signed in September 1980, DOE is to cost share in the project and to pay for equipment to monitor and collect data on the performance of the demonstration plant. DOE's cost in this project was limited to $70 million ($61.4 million for construction and plant operation, and $8.6 million to monitor and collect data on the performance of the project. The remaining $61.4 million of the plant's $122.8 million construction and operating costs are to be paid by SDG&E and its partners. 1/

As of January 1981 the Heber project was in the engineering design and early procurement phases, and was scheduled to be constructed by September 1984. The actual demonstration of the plant was being planned for a 2-year period expected to begin around April 1985. During that period, DOE was to monitor and disseminate the results of the plant's operations. Additionally, DOE was to share in the revenues from the plant after it began commercial operation.

However, with the recent change in administrations, there has been a proposed redirection in DOE's geothermal energy activities. DOE's activities are to be directed towards long-term, high-risk research and development, having high potential pay-offs, which industry will not undertake. Near-term development and commercialization of geothermal resources are to be left to private industry. Consequently, the budget proposed by the administration for DOE's fiscal year 1982 activities contains only $48.4 million for geothermal energy development compared to over $156 million appropriated for DOE's geothermal energy activities in fiscal year 1981. The fiscal year 1982 budget proposes numerous reductions and eliminations over a broad range of DOE's geothermal energy activities.

1/SDG&E formed a consortium to fund and operate the project. The consortium consists of SDG&E, the Electric Power Research Institute, the Imperial Irrigation District, Southern California Edison, and the California Department of Water Resources.

Among the activities for which Federal funding is to be eliminated is DOE's participation in the Heber demonstration plant. The budget proposal states that the project is being turned over to the private sector participants, and completion is to be determined by market forces.

WHAT IS THE POTENTIAL ENERGY CONTRIBUTION FROM HYDROTHERMAL RESOURCES, AND HOW IMPORTANT IS BINARY CYCLE TECHNOLOGY FOR PURPOSES OF REALIZING THAT POTENTIAL?

Geothermal energy, the internal heat of the Earth, is a theoretically inexhaustible energy source; however, current technology limits the use of geothermal energy to certain heat concentrations located in the upper portions of the Earth's crust. The heat concentrations are classified into five resource types--hydrothermal resources; geopressured reservoirs; hot dry rock; normal gradient heat; and magma, or molten rock. Extraction of energy from these resources is for the most part not yet economically or technically feasible; however, the generation of electricity from hydrothermal resources is near the point of widespread commercial development, and the use of these resources could play a significant role in meeting the Nation's future energy needs.

Hydrothermal resources consist of steam or hot water trapped in fractured or porous rock which has been heated by the Earth's interior. In instances where the hydrothermal resource is heated to temperatures of 150°Celsius (C) 1/ or higher, the capacity exists for the use of the resource for generating electricity. The U.S. Geological Survey has estimated that high-temperature hydrothermal resources may exist in the United States with the potential to generate 95,000 to 150,000 MWe, or approximately as much as one-fourth of the Nation's currently installed electric generating capacity. Additionally, all the identified high-temperature hydrothermal resources exist in the western States, which are experiencing some of the Nation's highest electric demand growth rates. Consequently, the development and use of hydrothermal resources for generating electricity can be an important factor in meeting the Nation's future energy needs and reducing its dependence on fossil fuels. DOE has estimated that as much as 25,000 MWe from geothermal powerplants could be on-line by the year 2000.

1/150°C is equivalent to 302° Fahrenheit.

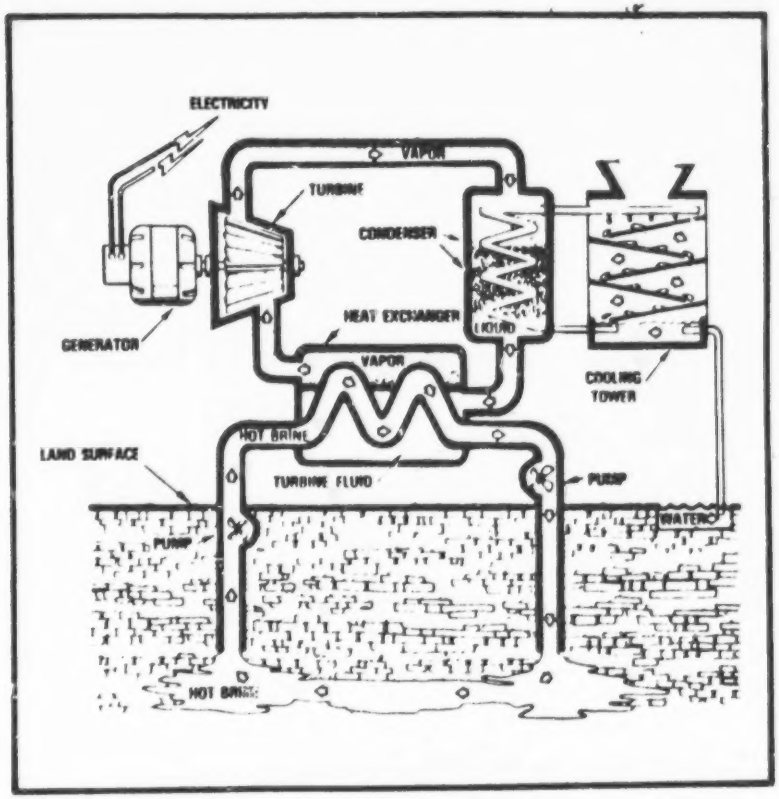
APPENDIX I

The development of technology to use hydrothermal resources to produce electricity is already underway. In fact, electricity is currently being produced at the Geysers in California, a hydrothermal steam resource of very high temperatures, and development is proceeding on hot water resources over 200^0 C to be used with flash-steam technology. Below this temperature level, the flash-steam technology cannot efficiently produce electricity. Binary cycle technology, however, has the potential for producing electricity practically from these lower temperature hydrothermal resources.

Binary cycle geothermal powerplants operate under different principles than the more conventional flash-steam plants. Flash-steam technology uses the higher temperature fluids which are brought to the surface by natural underground pressure. The decreased surface pressure causes the fluids to "flash" into steam to operate a conventional turbine. Binary cycle technology, however, pumps the fluids to the surface, and uses heat exchangers and a secondary working fluid to operate a turbine. Hydrothermal fluids must be pumped because of insufficient underground pressure to bring the needed amounts of fluids to the surface. The fluids are pumped through heat exchangers, transferring the heat to a secondary working fluid which vaporizes and drives a turbine. The working fluid is then cooled and condensed back into a liquid and routed back to the heat exchangers, completing the cycle. The following is a diagram of the operation of a binary cycle powerplant.

OPERATION OF A

BINARY CYCLE GEOTHERMAL POWERPLANT



Source: San Diego Gas and Electric Company

Binary cycle technology is expected to have a major impact on the use of hydrothermal resources for generating electricity. The technology has many potential benefits which include:

--Wide resource applicability. A study done by the U.S. Geological Survey in 1978 shows that approximately 70 percent of the identified high-temperature hydrothermal resources in the United States are between 150°C and 200°C. DOE and industry officials estimate that this figure is now approaching 80 percent with more recent discoveries of hydrothermal resources.

--Minimal environmental impacts. Since binary cycle powerplants are closed systems, no emissions from the geothermal fluid or the working fluid are expected to be released to the environment.

--Economic production of electricity. Although the cost of electricity from binary cycle plants cannot be predicted with a high degree of reliability, it is expected that the cost will be comparable to an oil-fired electric generating plant and possibly to a coal-fired plant in the near future, and therefore represent an economically viable use of hydrothermal resources.

--Providing a backup technology to flash-steam plants. In instances where hydrothermal resources cannot provide the temperatures needed to maintain the operation of a flash-steam plant, binary cycle technology may be substituted to produce electricity.

DOE and industry officials predict that binary cycle geothermal powerplants could provide approximately one-half of the 25,000 MWe which could be produced by geothermal powerplants by the year 2000. They cautioned, however, that this is contingent on the technology's development being accelerated by an aggressive Federal program.

Additionally, binary cycle technology has the potential to be used with other geothermal resources to produce electricity. According to DOE officials and industry representatives, binary cycle powerplants are likely to be used to produce electricity from geopressured resources (reservoirs of hot, pressurized fluids containing dissolved methane) and hot dry rock (resources containing geothermal heat but with an absence of water) when technology for using these resources advances to the point of commercial readiness.

WHY ARE BINARY CYCLE GEOTHERMAL POWERPLANTS NOT IN COMMERCIAL USE?

Although binary cycle technology has many potential benefits, the technology will become widely used only when it is accepted by the ultimate user--the utility industry--as a reliable and economic technology. However, the technology is not yet well-developed, and private industry commercialization efforts have not begun due to concerns over technical risks and economic uncertainties. While DOE does not believe that these concerns present major barriers to using binary cycle geothermal powerplants, the utilities we surveyed stated that such concerns serve to discourage their use of the technology.

Technical risks

Utilities require powerplants that operate reliably and efficiently in order to meet the power needs of their customers.

However, the use of binary cycle technology to produce electricity from hydrothermal resources is unproven, and the technical risks with the technology cause considerable concern over the ultimate reliable and efficient operation of binary cycle geothermal powerplants. Technical risks include:

--Performance problems associated with downhole pumps. Binary cycle technology requires the use of pumps located at the bottom of the hydrothermal wells. These downhole pumps are needed to bring hydrothermal fluids to the surface. The combination of high temperatures and pressures in the wells, however, have caused problems with the reliability of downhole pumps. While progress is being made on improving these pumps, DOE and utility officials stated that the past problems pose considerable risks to efficient operation of binary cycle powerplants. Because of the high cost of these pumps (between $100,000 and $150,000 per pump or higher), utilities do not view these risks lightly.

--Hydrocarbon handling and safety. Binary cycle technology uses a hydrocarbon as a working fluid. The hydrocarbon, usually isobutane or propane, is highly combustible. While it is believed that binary cycle systems will be safe under normal operations, there are nevertheless considerable concerns about the safety of the hydrocarbon fluids. Utility officials said that leaks, spills, or other problems associated with handling the hydrocarbon fluids could result in very dangerous situations.

--Hydrocarbon turbine efficiency and reliability. Binary cycle technology requires a large turbine to operate from the vaporized hydrocarbon fluids. According to DOE and utility officials, a large turbine designed to operate from hydrocarbon vapors has never before been built or tested. While sufficiently large turbines are expected to be available when needed, utility officials expressed reservations about the efficiency and reliability of the turbines once built.

Additionally, other concerns have been raised which are common to all hydrothermal technologies but which present additional problems to the viable operation of binary cycle geothermal powerplants. Hydrothermal fluids are corrosive, and contain dissolved solids which can cause scaling on the inside of the fluid piping system, thereby restricting the flow of the fluids and inhibiting heat transfer, thus reducing plant efficiency. Additionally, the withdrawal of hydrothermal fluids may cause the surrounding land to subside and reinjection of

fluids may contaminate ground water supplies, necessitating an interruption or termination of the plant's operation. These concerns are especially relevant to the binary cycl technology because it requires greater amounts of hydrothermal fluids in its process.

Utility representatives believe that all of these concerns pose severe impediments to their construction and use of binary cycle geothermal powerplants. They stated that these concerns could prove to be major obstacles to the effective operation of a binary cycle geothermal powerplant, and that concerns with binary cycle technology must be resolved before they would construct and use these plants.

In discussing these technical risks with DOE officials, they stated that, in their opinion, most of the risks were more perceived than real, but that the most crucial technical risk with the technology is developing reliable downhole pumps. According to these officials, DOE's geothermal component development activities are currently addressing the development of more reliable downhole pumps, and they hope to complete a 12-month reliability demonstration of an improved downhole pump by October 1983. They added that this effort, if successful, will greatly increase the probability of success for binary cycle geothermal powerplants. However, they pointed out that the utility industry will need to be shown that the downhole pump problems, as well as the less severe technical risks, are resolved before the industry will adopt the technology.

Economic uncertainties

A primary concern to the utility industry's use of binary cycle technology is the cost of the electricity produced by the plant. Current projections of the cost of power from binary cycle powerplants vary considerably, but most projections show that binary cycle powerplants could be economical in comparison to oil-fired powerplants. However, utilities have considerable concerns with the economics of binary cycle powerplants because of the unproven technology and the unknown capacity of the hydrothermal reservoirs.

Although a commercial-sized binary cycle powerplant has not yet been constructed, various studies have been made which have projected the cost of electricity from such a plant. We identified and examined four studies which discussed the projected busbar cost (the cost of electricity as it leaves the plant) of binary cycle powerplants. The cost projections arrived at by these studies were based on different assumptions and showed a wide range of costs for binary cycle powerplants. However, the

studies generally showed that binary cycle geothermal powerplants have the potential to be economically competitive with oil-fired powerplants. One study, prepared by the California Energy Commission in January 1981, projected that the busbar electric costs from a binary cycle plant commencing operation in 1985 may even be lower than the projected 1985 cost of oil-fired electric power generation. The most pessimistic study, prepared by DOE, compared a binary cycle geothermal plant to coal-fired and nuclear plants. The study projected that power from a binary cycle plant would cost twice as much as coal-fired or nuclear plants, but the study stated that a realistic potential exists for cutting these costs in half.

However, while binary cycle technology appears potentially competitive with oil-fired powerplants and eventually with coal-fired plants, utilities expressed considerable uncertainty over the economics of binary cycle plants. According to utility officials, the capacity factor of a powerplant is critical in determining its economics. The capacity factor of a powerplant is the percentage of total possible electric output actually produced by the plant. Utility officials stated that, to achieve economic busbar costs, a binary cycle plant will need to achieve capacity factors of 75 to 80 percent. However, because a commercial-sized binary cycle geothermal powerplant of 50 MWe has never been built and operated, the officials were concerned whether that capacity factor could be achieved. They stated that any technical impediment, particularly downhole pumps, hydrothermal fluid scaling and corrosion problems, or hydrocarbon leaks could seriously reduce binary cycle powerplant capacity factors and make the plant uneconomical.

Utilities were additionally concerned with the capabilities of the hydrothermal reservoirs. Utility officials pointed out that little is known about the long-term effects of operating a powerplant from a liquid-dominated hydrothermal reservoir. They stated that the economics of a binary cycle powerplant are based on an expected 30-year plant operating life. However, if production of electricity from a reservoir causes the temperature of the resource to substantially decline, electricity output from the plant may be seriously reduced or possibly terminated. Consequently, the economic potential of a binary cycle powerplant may not be realized.

WHAT PURPOSE WOULD BE SERVED BY THE HEBER BINARY CYCLE DEMONSTRATION PLANT?

The Heber binary cycle geothermal powerplant is needed by the utility industry to determine the viability of this

technology. Information on the operation of a commercial-sized binary cycle powerplant is vital to industry for assessing the technical and economic risks with the technology. Ongoing small-scale binary cycle efforts, while important, are not expected to provide the information needed. The successful operation of the Heber plant is expected to provide the necessary information to reduce the risks of using the technology and act as a stimulus to the near-term use of this technology to exploit the Nation's hydrothermal resources.

Virtually all segments of the infrastructure necessary to develop binary cycle technology we surveyed--utilities, geothermal developers, State public utility commissions, and lending institutions--stated that information from a successful demonstration of a binary cycle powerplant was needed to stimulate the use of hydrothermal resources with binary cycle technology. They stated that this demonstration is needed to determine if construction of binary cycle powerplants would be a prudent investment in terms of supplying reliable, economic electric power while providing an adequate return on investment. A 1978 DOE-sponsored survey of the geothermal industry by the Geothermal Resources Council supports the information we obtained. The study showed that approximately three-quarters of the industry surveyed believed that demonstration of a binary cycle powerplant was needed to assess the reliability and economic effectiveness of binary cycle technology.

Some small-scale binary cycle powerplant efforts are underway to provide information on the feasibility of such powerplants. The two most significant of these efforts are DOE's 5-MWe Raft River binary cycle pilot plant, located in Malta, Idaho, and Magma Power Company's 11-MWe powerplant, located in East Mesa, California. These plants are intended to help determine the feasibility, cost, and environmental impacts of binary cycle technology. However, these efforts have not been very successful and will not provide industry the information necessary to stimulate the commercial use of binary cycle powerplants.

Both DOE's and Magma's plants have had some successes, but both have encountered substantial problems. Although the Magma plant has been able to produce electricity from the binary cycle, it has been able to do so only at about half its expected output. Additionally, the plant has not operated for any extended length of time. The Raft River plant, which is using a resource approaching the minimum temperature needed for binary cycle use (150°C), has been successful in stimulating the production of fluid from geothermal wells. This plant, however, has yet to produce any electricity. Breaks in the piping system and problems with the operation

of downhole pumps, which according to officials connected with the Raft River plant have run an average of 14 minutes each, have prevented the initiation of steady operations. Officials stated that improved pumps are scheduled to be delivered in August 1981 and that the plant could begin to produce electricity in early fiscal year 1982.

Utility representatives stated that the Magma and Raft River plants have aided the development of binary cycle technology and with more successful operation could provide valuable information regarding the development of commercial binary cycle geothermal powerplants. However, they pointed out that these small-scale plants have a number of shortcomings which prevent them from reducing the risks of commercial use of binary cycle technology. Among the shortcomings mentioned are:

--The plants do not adequately demonstrate the type of turbine needed in the operation of a commercial-sized geothermal powerplant employing the binary cycle. The efficiency of a commercial turbine to operate from hydrocarbon vapors is still questionable, and the small-scale plants do not use nor do they demonstrate the necessary turbines.

--The economics of binary cycle geothermal powerplants are not proven by these efforts. The utility industry needs economic data which has high reliability, and the small-scale efforts do not provide that data.

--The past binary cycle efforts have been conducted as research and development and not in the mode of a commercial powerplant. Consequently, the small-scale plants do not use the technology and components needed in a commercial operation.

Utility officials believe that because of these shortcomings, the technical risks and economic uncertainties of geothermal powerplants using the binary cycle have not yet been effectively reduced.

Consequently, the Heber 50-MWe demonstration plant appears needed by industry to show the viability of binary cycle geothermal powerplants. According to DOE officials and industry representatives, the successful completion of this demonstration will provide the information needed to use this technology. The 50-MWe size of the plant is considered by industry to be the minimal size needed for economical commercial operation of a geothermal powerplant. This size requirement is supported by a DOE August 1980 study entitled, "Sourcebook on the

Production of Electricity from Geothermal Energy," which shows that the lowest cost of power from hydrothermal resources is achieved at powerplants sized 50 MWe or larger.

Because the Heber plant is to be commercial-sized, DOE and industry officials believe that reliable information on the economics of binary cycle geothermal powerplants can be attained from the plant. They also stated that this powerplant will show the efficiency of a full-sized turbine operating from the vaporized hydrocarbon fluid. Additionally, industry representatives pointed out that, in contrast to the current small-scale binary cycle efforts, the Heber plant is to be built and operated as a commercial powerplant.

Many industry representatives stated that the completion and operation of the Heber 50-MWe powerplant is even more critical because of the proposed termination of DOE's geothermal loan guarantee program. 1/ The program provided loan guarantees up to 90 percent of the project amount for qualified geothermal projects. The representatives stated this program could have helped reduce the risks of using binary cycle geothermal powerplants. However, without such a program, the risks of using this geothermal application would all rest with industry. Consequently, the technical and economic viability of binary cycle geothermal powerplants must be well-proven by a demonstration plant before industry will undertake its use.

WHAT ARE THE PROSPECTS FOR PROJECT CONTINUATION AND FURTHER DEVELOPMENT AND USE OF HYDROTHERMAL RESOURCES ONCE FEDERAL PROJECT FUNDING IS ELIMINATED?

Without Federal participation in funding of the Heber 50-MWe geothermal demonstration plant, it appears that industry will not continue the development of the plant. Consequently, the use of binary cycle technology to generate electricity from hydrothermal resources will be delayed, and the ultimate development and widespread use of these resources impeded.

1/The geothermal loan guarantee program was created to encourage and assist the commercial development of hydrothermal resources. To date, the program has issued loan guarantees for five geothermal projects. However, the administration has proposed in DOE's fiscal year 1982 budget request to terminate this program.

APPENDIX I

Withdrawal of Federal funding could result in project termination

The administration is planning to eliminate Federal funding for the Heber demonstration plant. The administration's justification for this action is stated in DOE's fiscal year 1981 revised request to the Congress for supplementals, recissions, and deferrals as follows:

> "* * * the rescission terminates funding for the * * * demonstration plant at Heber, California employing binary technology * * *. These reductions are justified because commercial efforts in the private sector are now well developed, along with near-term R&D, and can be supported there. Additionally, reliance should be placed on the private sector for the necessary funding for demonstration plants, therefore, cancellation of the * * * demonstration plant at Heber, California is appropriate."

Private industry, however, has stated it will not complete the Heber project without Federal funding support. Industry officials connected with the Heber demonstration project stated that the withdrawal of Federal funding for the project will create a funding void which cannot be replaced and, as a result, the project will be abandoned.

SDG&E representatives stated that Federal funding is crucial to the completion of the Heber plant. They stated that they have attempted to obtain total utility industry funding for this project on two occasions, but that these efforts were unsuccessful because of the risks perceived with this first-of-a-kind project. These representatives pointed out that SDG&E has obtained funding from two other utilities, the State of California and the Electric Power Research Institute, but that additional funding does not appear possible due to current financial constraints facing the utility industry. Consequently, without the necessary funds, SDG&E and its partners will be forced to terminate the Heber project.

In discussing the possible termination of the project with SDG&E and other utility industry representatives, they stated that the withdrawal of Federal funding for the project is unjustified. They stated that, contrary to the administration's stated justification, private industry cannot support the binary cycle demonstration project. They stated that the utility industry is having difficulties in obtaining capital to construct plants which use proven technology. In their opinion, the risks of undertaking this $122.8 million project are

too high for private industry alone, and the Federal Government should maintain its support of the project to reduce these risks to a level acceptable to industry if binary cycle geothermal powerplants are to make a contribution in the near-term.

SDG&E representatives added that, although DOE was sharing in the costs and risks of the first commercial-sized binary cycle geothermal powerplant, the agreement between SDG&E and DOE permitted DOE to recover most of its costs if the plant is successful. Under the agreement, DOE shares equally in the revenues of the plant, and SDG&E representatives estimate that, if the plant does achieve successful operation, DOE could recover as much as $51 million in 10 years. SDG&E representatives stated that this revenue projection was optimistic, but they are hopeful it can be attained.

Termination of Heber project will delay use of binary cycle geothermal powerplants

The termination of the Heber binary cycle geothermal demonstration project will result in a delay in using the binary cycle technology to develop the Nation's hydrothermal resources. While there is no hard data on the impact the termination of the plant could have, representatives of the utility industry, DOE, and the Electric Power Research Institute, believe a termination of the project could delay the use of binary cycle geothermal powerplants until the 1990s.

The utilities we contacted indicated that the termination of the Heber project will delay their use of the binary cycle technology considerably. Utility representatives told us that while they currently do not have firm plans for using binary cycle geothermal powerplants, they would like to include binary cycle powerplants in their future powerplant construction plans. They added that if the reliability and economics of such plants prove satisfactory, they would construct binary cycle powerplants rather than coal, oil, or nuclear powerplants. They pointed out that some States, such as California, have passed laws which effectively prohibit the construction of new coal-fired and nuclear powerplants and consequently alternative powerplants are needed. They added that binary cycle powerplants have several advantages, such as being (1) constructed in shorter time frames than other powerplants, (in as short as 3-5 years, compared to as long as 14 years for coal-fired and nuclear powerplants) and (2) built in 50-MWe increments, with additional increments being constructed when needed as opposed to other type plants which are usually constructed in much larger sizes. Without information from the Heber plant, however, the reliability and economics will not be demonstrated

and utilities will not have the necessary information on binary cycle powerplants when making decisions on their future powerplant construction plans. Consequently, the use of binary cycle geothermal powerplants will be delayed until this information is available.

A number of utility representatives estimated that, with the successful operation of the Heber plant, binary cycle geothermal powerplants could begin filling electricity needs in the late 1980s. However, they estimated that without the project, the delay in using the technology could be 8 to 10 years. They believe it will take that long before the utility industry is willing and able to undertake the necessary demonstration project because of the high-risks of constructing the first commercial-sized plant. They estimated that, at a minimum, it will not be until the late 1990s before binary cycle geothermal powerplants begin to be commercially used and, at worst, could be delayed indefinitely.

DOE geothermal program officials generally agreed with the views we obtained from utility representatives. These DOE officials said that, in their original justification for participating in the Heber project, it was estimated that the plant would accelerate the commercial use of the binary cycle technology by 2 to 4 years. However, these officials now believe that a termination of the project could result in a delay of longer than 4 years, and that industry's estimate of an 8 to 10 year delay is not unrealistic. DOE officials, nevertheless, maintain that the administration's position is that private industry and not DOE should commercialize this technology, and market forces will determine the appropriate time for its use.

The Electric Power Research Institute, the research arm of the electric utility industry, estimated that the termination of the project would substantially reduce the amount of electric power expected to be produced from geothermal powerplants by the year 2000. An Institute official who has taken annual surveys of utilities' long-range plans for geothermal energy use estimated that the termination of the Heber project will result in at least a 40-percent reduction in the installed capacity of geothermal powerplants by the year 2000. Based on the Institute's latest utility survey, the possible installed geothermal capacity by the year 2000 will therefore be reduced from 10,000 MWe to 6,000 Mwe.

Consequently, while the impact of the potential termination of the Heber demonstration project cannot be fully quantified, it is generally believed that a signficant delay in the commercial use of binary cycle geothermal powerplants

will occur. As a result, full development of the potential of hydrothermal resources for generating electricity will be impeded and benefits which could result from the sizable Federal investment in binary cycle geothermal technology--amounting to $121 million in the past 4 years--may not be attained.

CONCLUSIONS

To determine the potential effects the administration's proposed elimination of Federal funding for the Heber 50-MWe binary cycle geothermal demonstration project could have on the further development and use of hydrothermal resources for generating electricity, we addressed a number of questions. We found that, if Federal funding for the Heber project is eliminated, there is little likelihood that the project will continue, which will result in a delay in using binary cycle technology to develop hydrothermal resources. Consequently, the full development and widespread use of hydrothermal resources will be impeded.

The Nation's hydrothermal resources could have the potential to generate as much as 150,000 MWe. DOE has estimated that about 25,000 MWe from hydrothermal resources could be on-line by the year 2000. Binary cycle geothermal technology can play a major role in exploiting this potential. The large majority of these resources are at temperatures which can be effectively used only with binary cycle technology.

However, there are a number of technical risks and economic uncertainties to using binary cycle geothermal powerplants. The most critical technical risk is the currently unreliable performance of the downhole pumps needed to obtain the fluids from the hydrothermal resources. The economics of binary cycle geothermal powerplants is uncertain due to the unknown cost and performance of these powerplants, and is further complicated by questions relating to the long-term energy capacities of hydrothermal reservoirs.

The utility industry has indicated that it needs a commercial-sized demonstration plant to verify the viability of binary cycle technology. The small-scale efforts currently underway, while considered important, do not provide the technical and economic data the industry needs to promote the widespread commercial use of binary cycle powerplants. The utilities need the Heber 50-MWe plant because it is a commercially viable size which could provide the needed information on the vital components of a binary cycle powerplant and the viability of the binary cycle technology.

Elimination of Federal funding for the Heber project could, however, cause the project to be terminated. DOE was funding one-half the construction and operating costs of the plant, however, withdrawal of Federal funding will create a void which cannot be replaced by industry. The private industry participants cannot obtain additional funding because of the high-risks associated with this first-of-a-kind project. Consequently, the project participants plan to terminate the project if Federal support is withdrawn.

If the Heber project is terminated, the use of binary cycle geothermal powerplants will be delayed. Industry needs the demonstration in order to make decisions on the use of this technology in conjunction with its future powerplant construction plans. Without the demonstration, industry believes that the use of binary cycle powerplants will be delayed 8 to 10 years or longer. Another estimate projects that the capacity of geothermal powerplants on-line by the year 2000 will be reduced by 40 percent. Consequently, the full development and widespread use of hydrothermal resources to reduce the Nation's dependence on fossil fuels will be impeded.

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As our report was nearing completion, actions were initated in the Congress to continue Federal participation in the Heber binary cycle geothermal demonstration project. The House Committee on Science and Technology, in its report on H.R. 3146, the House bill to authorize appropriations to DOE for civilian research and development programs and projects for fiscal year 1982, increased DOE's authorization request by $8 million to restore participation in the Heber demonstration project. Additionally, the Senate Committee on Energy and Natural Resources, in its report on S. 1021, the Senate bill to authorize appropriations to DOE for civilian programs for fiscal year 1982, authorized the continuation of capital expenditures for the Heber demonstration project.

The results of our work support such action. The Heber project provides an opportunity to begin achieving the widespread use of binary cycle technology and bring to fruition the Federal investment, approximately $121 million in the past 4 years, in developing the technology. Because of technical and economic uncertainties, continued Federal participation appears necessary for the project to proceed and act as a catalyst in reducing the risks and stimulating the use of binary cycle geothermal powerplants. It is worth noting in this regard that, if the project is successful, the majority of the

Federal funds in the project could be recovered from plant operations.

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